

Western Tasmanian Regional Minerals Program  
Devonian Granite Aureoles Project

Devonian granitoids and  
prospective copper, tin and gold,  
northwestern Tasmania

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## Summary

- It is probable that polymetallic, tin-bearing veins and breccia that occur over an area of several square kilometres around Specimen Hill, near Balfour (fig. 2, 3), are of Devonian age.
- A Devonian age is also probable for narrow, copper-bearing lodes and magnetite-bearing lodes in the Pieman Heads–Toner River–Nelson Bay River region, which includes Balfour. The magnetite-bearing lodes around Temma and Nelson Bay River comprise relatively high-temperature skarn assemblages.
- The presence of a granite porphyry dyke of known Devonian age at Timbs Creek makes a Devonian age likely for the granitic intrusion breccia and associated gold-bearing alteration system at Lucy Spur. Other gold-bearing alteration systems in the district may also have a relationship with Devonian magmatism.
- Opportunities exist for further testing of the copper-bearing lodes at Balfour by deeper drilling (below 120 m). Other opportunities for drill testing of the copper-bearing lodes may exist at Balfour South and Dohertys Pimple.
- An excellent opportunity exists for further exploration of the tin resources at Specimen Hill and in the surrounding several square kilometres of country. Mineral Resources Tasmania has identified several new HEM anomalies in this area.
- West of Specimen Hill there are defined lead/zinc anomalies  $\geq 1$  km in length that have not been drill tested.
- The belt of faulted country between Corinna and Specimen Reef includes two known gold-bearing alteration systems and represents an attractive target for further gold exploration, particularly as the fault complex cuts potentially reactive Neoproterozoic carbonate formations. A similar opportunity exists at Roger River where there are similar geological features.

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## Introduction

In the period 2000 to 2002, Mineral Resources Tasmania (MRT) acquired a substantial body of new aerial geophysical data as part of the Western Tasmanian Regional Minerals Program (WTRMP). These new data, together with MRT's existing databases, have been utilised in several thematic projects that aim to highlight mineral exploration opportunities in western Tasmania. Both MRT personnel and independent geologists and geophysicists have participated in the generation and execution of the projects.

This report is one of a series of reports relating to a thematic project that deals with the prospectivity of the Devonian granite aureoles in western Tasmania. These aureoles are widely recognised for world-class tin and tungsten deposits and also contain significant occurrences of other metallic and industrial commodities. The work that has been carried out illustrates the regional setting of known granite-related mineralisation against the backdrop of MRT's new and existing data. The work also illustrates the setting, geophysical features and prospectivity of selected occurrences of granite-related mineralisation at a more local scale.

The results of the December 2002 to April 2003 round of work on the Devonian Granite Aureoles Project are presented in four reports. This report discusses mineralisation in northwest Tasmania (fig. 1), in terms of its possible relationship to Devonian granitoids, and highlights areas of interest for exploration.

### Granitoid-related deposits in western Tasmania

Report 1 in this series of reports on mineralisation in the Devonian granite aureoles in western Tasmania

(Morrison *et al.*, 2003a) illustrates how most of the recognised, granitoid-related mineral deposits occur either close to outcropping granitoids, or within them. The outer boundary for these mineral deposits, which may include tungsten, tin, magnetite, base metals, gold and other replacement and vein deposits, is generally approximated by the 4 km depth-to-granitoid contour as modelled from regional geophysical data by Leaman and Richardson (1992, 2003). Deposits are particularly numerous in areas where the erosion level is such that the country rocks overlying the source granitoids are still intact, or substantially so. These areas include the Zeehan field, Moina and the western margin of the Housetop Granite.

Zoning of granite-related deposits can be marked, notably in the Zeehan field and around Moina, but in other areas as well (Collins *et al.*, 1989). At Zeehan the zoning is thought to be centred on the Queen Hill–Montana–Severn cassiterite-sulphide deposits, which are surrounded by argentiferous galena and sphalerite vein deposits. On geophysical evidence, a shallow (900 m) cupola of granite is interpreted to underlie the Queen Hill–Montana–Severn deposits (Anderson, 1986). At Moina zoning is centred on the small outcrop area of the Dolcoath Granite. There is an inner cluster of wolframite-cassiterite (-molybdenite) deposits that passes outwards to cassiterite-wolframite-bismuthinite deposits, then bismuth-gold and silver-lead deposits (Jennings, 1965; Morrison *et al.*, 2003b).

Carbonate-rich rocks at several levels in the Proterozoic to mid-Palaeozoic stratigraphy reacted strongly with the granite-derived mineralising fluids and were thus a key factor in localising mineralisation to form the major deposits, including Grassy–Bold Head (W) on King Island, Mt Bischoff (Sn) and Renison (Sn). Faults provided conduits for the passage of

mineralising fluids into the country rocks in many cases. This is particularly well demonstrated in the case of the cassiterite-sulphide deposit at Renison (Morland, 1989), and appears to be the case with the silver-lead-zinc deposits that cluster along the Henty Fault where it crosses the inferred, shallow, subsurface granite ridge that extends from Mt Heemskirk to Granite Tor. The Merton Hill deposit of tin-lead-zinc-silver (Green *et al.*, 1988) lies well outside the 4 km depth-to-granite contour, suggesting that structure was particularly effective in aiding the passage of the mineralising fluids that formed the deposit.

In the area of interest to this report (fig. 1), the Nolan Creek anomaly (fig. 2) is a feature that falls within the 4 km depth-to-granite contour of the Meredith Granite, but has not been extensively explored. It is a stream sediment anomaly occupying an area of 8 km<sup>2</sup> (Penny *et al.*, 1984; Turner, 1998), with the upper reaches of Nolan Creek at the western margin. The anomalous metals are silver, lead, arsenic, antimony and bismuth. This suite is consistent with the source of the anomaly being a Devonian silver-lead occurrence. The host rocks comprise folded and slightly metamorphosed, impure sandstone and carbonaceous siltstone of the Oonah Formation.

Elsewhere in northwest Tasmania there are occurrences of magnetite, tungsten, tin, gold and base metal mineralisation that fall both inside and outside the geophysically-modelled 4 km depth-to-granite contour.

## **Granitoids in northwest Tasmania**

### *Large granitoid intrusions*

The principal outcropping granitoid bodies in northwest Tasmania (fig. 1) are the Meredith Granite, Pieman Heads Granite, Interview Granite and the Sandy Cape Granite. Recent mapping by Mineral Resources Tasmania (John Everard, pers. comm., 2003) has shown that the northern boundary of the Interview Granite is located at about 5 403 000 mN, rather than the 5 409 000 mN shown in Figures 1 and 2.

The geophysical interpretations of Leaman and Richardson (1992, 2003) place an extension of the Three Hummock Island Granite at considerable depth beneath far northwest Tasmania and identify a substantial body of granitoid at shallow depth in the vicinity of Norfolk Range. Webster (2002) supports the interpretation of shallow granitoid in the vicinity of Norfolk Range, and also suggests that an intrusion of ?Cambrian age is present at 1–2 km depth beneath a domal structure of outcropping Rocky Cape Group in the gravity low at Jims Plains (Seymour and Baillie, 1992; fig. 2).

Geophysical interpretation indicates that the western contact of the Meredith Granite dips steeply, and that granite is either not present beneath the Corinna district (fig. 2) or is present at a depth of greater than nine kilometres. West of Corinna, granite rises towards the outcropping Pieman Heads and Interview

Granites. Throughout most of the rest of northwest Tasmania the depth to any major granite bodies, if present, is interpreted to be greater than nine kilometres.

### *Timbs Creek granite porphyry*

A small felsic porphyry body intrudes Cambrian metamorphic rocks in Timbs Creek, at a locality some eight kilometres northeast of Corinna (fig. 2). The porphyry has a massive, very fine grained groundmass that surrounds small, rounded and embayed phenocrysts of quartz and feldspar. It has a mid-Devonian SHRIMP zircon age of 380 ±6 Ma (Turner *et al.*, 1998), which is probably a little older than the AG/MRT SHRIMP zircon age (L. P. Black and M. P. McClenaghan, pers. comm., 2003) of 372.6 ±2.1 Ma from the Meredith Granite and clearly older than their 361.1 ±2.4 Ma age from the Sandy Cape Granite.

The Timbs Creek porphyry is six kilometres west of the Meredith Granite contact and is at a modelled distance of greater than nine kilometres above any underlying mass of granitoid. Its presence demonstrates that Devonian magmatism found expression at locations that are relatively remote, both laterally and vertically, from the modelled bodies of granitoid.

The porphyry has the major element composition of granite. It contains 1 ppm Cu, 64 ppm Pb, 15 ppm Zn, 0 ppm Sb, 5 ppm Sn and 0 ppm W. It also contains abundant disseminated pyrite and has a sulphur content of 0.69%. Notable barium of 461 ppm is present. The gold content is unknown.

## **Gold — Specimen Reef to the Pieman River**

### *Alluvial gold and its possible sources*

The country between Specimen Reef and the Pieman River (fig. 1, 2) includes much of the southern part of the Arthur Metamorphic Complex together with the Ahrberg Group (Seymour and Calver, 1995). The Arthur Metamorphic Complex is a northeast-trending belt of Cambrian-aged, mainly greenschist facies, mylonitic metamorphic rocks derived from argillaceous and subordinate quartzose, clastic sedimentary rocks, basic igneous rocks and minor carbonate rocks of probable Mesoproterozoic and Neoproterozoic age. The lower grade Ahrberg Group is of Neoproterozoic age and also contains clastic sedimentary rocks and basic igneous rocks, but includes extensive carbonate formations that are not present in the Arthur Metamorphic Complex. The Ahrberg Group lies west of the Lefroy Ridge Fault and extends northeast through Corinna and Brookside, and into the area west of Specimen Reef.

Almost all of the gold that has been produced in northwest Tasmania was won from the alluvial deposits of Recent and Tertiary age that are developed over the southern part of the Arthur Metamorphic Complex and the Ahrberg Group. Microscope studies of the shape characteristics of a suite of alluvial gold

grains representative of a range of localities across the district show that a large proportion of grains exhibit little evidence of travel damage, and are probably of local derivation (Nolan, 1996). Petrographic and microprobe studies of the same suite of grains suggest that the gold was initially formed in a range of mineralising systems (Kitto, 1996).

Alluvial grains from the Rocky River, where it crosses a distinctive magnetite/pyrite-rich unit (Bowry Formation) of the Arthur Metamorphic Complex, include intergrowths of gold and goethite (after pyrite  $\pm$  pyrrhotite) that indicate coeval deposition of gold and sulphide minerals (Kitto, 1996). The presence of chalcopyrite and galena inclusions in some gold grains support this view, as does the presence of anomalous gold and copper in magnetite/pyrite-rich intervals in drill core from Rocky River (Turner, 1998). Substantial coarse gold has been won from the Rocky River, including McGinty's 7.5 kg nugget (Julen, 1981) and a considerable number of smaller nuggets, with some examples consisting of gold intergrown with magnetite and oxidised sulphide.

Carbonate inclusions in some gold grains support a carbonate replacement style of mineralisation or gold-carbonate veins. Rutile, minor spinel and possible K-feldspar inclusions could reflect mineralisation associated with metamorphism or with felsic intrusive rocks, while rare platinum inclusions may suggest an ultramafic association. Fineness values for the suite of alluvial gold grains are high, consistent, show narrow ranges, and are similar to values for the Archaean, Slate Belt and Plutonic categories of gold mineralisation (Kitto, 1996).

### ***Pre-deformational hard-rock gold – Bowry Formation***

Pre-deformational (pre-dating the dominant, Cambrian, regional schistosity  $S_1/S_2$ ) and post-deformational gold-bearing systems both occur in the southern part of the Arthur Metamorphic Complex and in the Ahrberg Group. The former relate to the Bowry Formation and include low order, Au-Cu anomalism associated with pyrite (+magnetite)-rich intervals in drill core from Rocky River. A siliceous ironstone from near the eastern edge of the Bowry Formation at the Owen-Meredith rivers was found to contain up to 0.29 g/t Au and 0.12% Cu (Herrmann, 1991a). South of the Pieman River, at the Alpine anomaly, there is substantial copper in a magnetite/pyrite-rich part of the Bowry Formation, including a best intersection from two drill holes of 27.4 m at 0.53% Cu, but gold is low (e.g. 0.105 g/t; Herrmann, 1991b). Veined, zinc-bearing intervals, including 8.2 m at 0.19% Zn and 0.04% Cu, occur above the copper-bearing intervals in each hole. The relationship between the two types of mineralisation is not understood.

### ***Post-deformational hard-rock gold – Lucy Spur***

In historical times post-deformational gold mineralisation in the southern part of the Arthur Metamorphic Complex was mined and prospected in small underground workings at Lucy Spur, Golden Ridge and Specimen Reef (fig. 2). Hard-rock gold at the Lucy Spur hydraulic workings, and one kilometre to the south at the Lucy Spur adits, is present in quartz-sideritic carbonate-sulphide veins that occur in altered schist and in an intrusion breccia consisting of hydrothermally-altered, partially rounded, country rock blocks contained in a massive, flow-textured, hydrothermally-altered, granitoid matrix. Gold values of +1 g/t have been returned from two metre channel samples at the hydraulic workings, and an exceptional value of 102 g/t was returned from a rock chip of a thin limonite (after sulphide) vein collected in the southern adits (Terry, 1998).

The matrix of the intrusion breccia exhibits intense hydrothermal phyllic alteration of a granitic precursor (Leach and Corlett, 1998). An alteration assemblage of quartz-muscovite/coarse sericite-pyrite is consistent with relatively high temperature hydrothermal fluids, and the presence of trace andalusite indicates fluid temperatures in excess of 300-350°C. Tourmaline, topaz and apatite are present, while gold, silver, copper, arsenic, antimony, bismuth and molybdenum are anomalous in the alteration system.

### ***Post-deformational hard rock gold – Golden Ridge and Specimen Reef***

Post-deformational gold at Golden Ridge occurs as intermittent patches in thin, cross-cutting, quartz-carbonate veins (Twelvetrees, 1903), apparently with little associated alteration. In contrast, drilling at Specimen Reef demonstrated 50 m of intense, post-deformational, sideritic, sericitic and siliceous alteration around the fault that contains the reef breccia, which returned two metres at 0.5 g/t gold (Turner, 1997c). Patchy alteration extended another 170 m to the collar of the hole on the eastern side of the reef.

The alteration is related to a sheeted system of veins that are sub-parallel to the reef. These veins contain brown sideritic carbonate, white carbonate, quartz and pyrite. A narrow, very rich gold intersection of 0.2 m at 910 g/t was obtained from these veins at a point east of the reef (Newnham, 1996). This rich gold is accompanied by the uranium mineral brannerite (Sharpe, 1998), but very little other metal is present in the Specimen Reef system. Analysis of the records of the old workings by Newnham (1996) suggests that good gold grades were obtained in the mined parts of the reef, which consisted of siderite, quartz and pyrite with a little chalcopyrite. A little vivid green mica (?fuchsita) is also present in the reef. Sharpe (1998) concluded that the alteration and gold mineralisation at Specimen Reef show many similarities to Archaean

and Proterozoic, quartz-carbonate, shear hosted gold deposits.

Specimen Reef strikes northeast and dips about 50° southeast. Aeromagnetic interpretation indicates that, on either side of the old workings, there may be up to two kilometre long strike extensions of the fault that contains the reef (Leaman, 1998). The fault appears to be part of the complex of north to northeast-trending faults that includes the Donaldson Fault (fig. 2). Despite the presence of brannerite at Specimen Reef, no radiometric feature corresponding to the reef has been recognised in MRT's new radiometric coverage.

### ***Post-deformational hard rock gold – Brookside***

The complex of north to northeast-trending faults that includes the Specimen Reef structure and the Donaldson Fault also includes the Lefroy Ridge Fault and the Brookside Fault. The latter structure (fig. 1, 2) trends northeast from the Pieman River just west of Corinna to the old Brookside workings; south of the Pieman River it is covered by Tertiary deposits. Basalt and fine-grained sediments of the Bernafai Volcanics to the west are faulted against Corinna Dolomite to the east.

Between the Pieman River and the Brookside workings the fault coincides with a linear potassium radiometric anomaly that is evident in MRT's new geophysical data (fig. 3). At several points there are also uranium radiometric anomalies on the fault. Both the potassium and the uranium anomalies are at a maximum near the Brookside workings, where there is also cross faulting. The radiometric anomalies are taken as indicators of alteration associated with the Brookside Fault, which in the limited exposures available comprises deeply weathered clays containing secondary limonite and goethite and fine-grained silicified material.

Running parallel and adjacent to the Brookside Fault on its eastern side is Middletons Creek (fig. 2, 3), which supported the first round (from 1879) of alluvial mining in the district and was worked again in the 1930s (Blake, 1939). Like other alluvial deposits in the district Middletons Creek contains gold that was probably derived from the nearby Tertiary deep lead and gold that was probably locally derived. In particular, Blake (1939) notes that a face developed on a western branch of the headwaters returned numerous small nuggets of 2–5 dwt. This face would have been in, or near, the uranium radiometric anomaly that coincides with both the Brookside Fault and the headwaters of Middletons Creek (fig. 3). It is likely that the coarse gold was derived from the alteration zone in the Brookside Fault, either directly or indirectly via colluvium.

Consistently fine-grained crystalline gold has been identified in residual soils that overly the Brookside Fault at the Brookside workings (Large, 1987). Limited shallow drilling has been carried out in the vicinity of Brookside (Henham, 1990; Turner, 1997a). This drilling

did not test the radiometric features at Brookside, but demonstrated anomalism of gold, silver, copper, lead, zinc, arsenic, antimony and mercury in the Brookside Fault, and in dolomite, volcanic rocks and residual silica deposits to the east of the Brookside workings. The residual silica deposits consist of very pure quartz sand and quartz silt that are currently being mined as very high purity 'silica flour'. These silica deposits are widespread over the Corinna Dolomite and the nearby Savage Dolomite, and contain fragments of vein quartz as well as banded quartz that is known locally as 'lacy agate'.

Fluid inclusion studies (Khin Zaw *et al.*, 1992) of material from the silica flour deposits indicate an early phase of quartz vein formation at about 300°C, followed by lacy agate formation and dolomite silicification at about 250°C, then an event (?leaching) at <150°C. Taken together, the silica alteration of dolomite, the temperature of alteration, and the suite of anomalous metals support the presence of a Carlin-style mineralising system (see also Large, 1987; Bottrill *et al.*, 1992; Morrill, 1997). Kitto (1997) characterised the mineralising agency at Brookside as a relatively high temperature, chlorine deficient, near-neutral pH, low salinity, sulphur-bearing, reduced and over-pressured CO<sub>2</sub>-rich hydrothermal fluid. Mixing of this fluid with cooler meteoric fluid brought about precipitation of gold, supersaturation in silica, dissolution of dolomite and deposition of quartz.

### ***Hard-rock gold and granitoids***

The gold-bearing, hard-rock settings in the Specimen Reef–Pieman River district include:

- Bowry Formation: Pre-deformational; pyrite (+magnetite)-rich intervals with anomalous Au/Cu.
- Lucy Spur: Post-deformational; granitic intrusion breccia; quartz/muscovite/pyrite (trace andalusite) alteration; quartz/sideritic carbonate/pyrite veins; anomalous Au, Ag, Cu, As, Sb, Bi, Mo.
- Golden Ridge: Post-deformational, cross cutting quartz/carbonate veins.
- Specimen Reef: Fault-hosted reef and parallel sheeted veins; sideritic/sericitic/quartzose alteration; sideritic carbonate/white carbonate/quartz/pyrite/trace fuchsite in reef and veins; anomalous Au, one known occurrence of U.
- Brookside: Fault related; silica alteration of dolomite; anomalous Au, Ag, Cu, Pb, Zn, As, Sb, Hg.

Of the post-deformational, gold-bearing hydrothermal systems that have been identified at Lucy Spur, Specimen Reef and Brookside, only the Lucy Spur system is clearly granite related, but it is of unknown age. The presence of the Devonian intrusive porphyry at Timbs Creek makes it likely that the Lucy Spur intrusion breccia and hydrothermal system are also of Devonian age. Although Kitto (1997) favoured a deep metamorphic origin for the hydrothermal fluid at Brookside, citing a lack of evidence for mesothermal intrusions and associated hydrothermal fluid sources in the district, the nearby presence of the Timbs Creek porphyry and the Lucy Spur intrusion breccia makes it more likely that the genesis of the Brookside and Specimen Reef systems was ultimately linked to Devonian granitoids.

Of particular interest to mineral exploration is the presence of two recognised, gold-bearing, hydrothermal systems (Brookside, Specimen Reef) within the complex of faults that extends through the Corinna and Specimen Reef areas. Their presence makes the entire belt of country along the fault complex from Corinna to Specimen Reef an attractive exploration target for gold, particularly as a number of potentially reactive carbonate units in the Ahrberg Group are cut by the fault complex along this interval (fig. 1).

### **Roger River alteration zone**

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An alteration zone extends northeast along the Roger River Fault (fig. 1, 2) from Roger River West through Roger River to just east of Edith Creek, a distance of about seven kilometres (Turner, 2003). The southern three kilometres of the zone is 200–300 m wide and is characterised by fine and medium-grained, hard siliceous rocks that commonly exhibit breccia textures, but may also be massive or vughy. In several shallow quarries moderately dipping silicified bands are regularly interlayered with intervals of pale clay and such sequences are thought to be after bedded dolomite (see Lennox *et al.*, 1982). Silicification is minor and discontinuous in the northern part of the zone and is absent east of Edith Creek, where the alteration zone consists of soft, pale, sericitic material in which an euhedral, porphyroblastic silicate mineral is locally common.

Zinc, arsenic and antimony are sporadically anomalous along the northern part of the alteration zone and low order values of gold may be present. Low order values of gold, arsenic and antimony are also sporadically present in the southern silicified section, where values of up to 1.5 ppm Hg and 6% Ba have also been obtained. Zinc and other base metals are unusually low in parts of the southern silicified section, possibly reflecting hydrothermal leaching. Adjacent to the Roger River Fault southwest of Roger River, near the Arthur River, there are substantial deposits of silica flour like those at Brookside. Similar silicification is widespread along the strike of the

upper formation of Neoproterozoic carbonate rocks southwest and west of these deposits (fig. 1).

There are some marked similarities between the Brookside and Roger River areas. In each area regional faults of northeasterly trend cut the same Neoproterozoic successions of clastic sedimentary, basaltic and carbonate rocks. There is extensive silicification of carbonate rocks together with metal anomalism that includes gold, arsenic, antimony and mercury. There has been no drilling at Roger River and minimal drilling around Brookside.

The age of the Roger River alteration zone is unknown. It could be quite young if it is related to the metalliferous spring mound deposits of Recent age that occur in the Edith Creek–Irishtown area (Morrison, 2002). Similar spring mound deposits have not been identified in the district that includes Brookside whereas granitoid-related mineralisation and Devonian igneous activity have been demonstrated.

### **Jims Plains**

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The intrusive body interpreted by Webster (2002) to be at 1–2 km depth beneath the dome of Rocky Cape Group rocks at Jims Plains provides a possible source for the nearby, minor silver and zinc mineralisation. It may also be significant in terms of potential for mineralisation in the Neoproterozoic carbonate rocks of the Smithton Synclinorium over a wider area. A possibly Cambrian age is assigned to the intrusive, which is consistent with the Leaman and Richardson (1992, 2003) model of the depth to major Devonian granite being greater than the depth of the intrusive. In view of the sparseness of gravity stations in the area (fig. 2) both these geophysical interpretations may be subject to revision.

### **Pieman Heads–Toner River–Nelson Bay River**

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#### *Structure*

Unlike other major Devonian granitoid bodies in western Tasmania, the outcropping part of the Interview Granite (fig. 2) has a NNW-trending, dyke-like form with steeply dipping eastern and western contacts (Ward, 1911; Gee *et al.*, 1969). Geophysical interpretation (Leaman and Richardson, 2003) suggests that the granitoid body is not simply tabular but broadens at depth, although it remains highly elongate. Another granitoid with a similar, NNW-trending, spine-like intrusive form is inferred to underlie the Norfolk Range and country to the NNW at shallow depth (fig. 2; Webster, 2002; Leaman and Richardson, 2003). The Norfolk Range granitoid is entirely a geophysically-derived feature, having not yet been substantiated by direct field evidence such as, for example, thermal metamorphism in the Proterozoic sedimentary rocks of the Norfolk Range.

The strong northwesterly structural trend that is exhibited by the Interview Granite is also reflected in narrow, copper-bearing and magnetite-bearing lodes that are regionally extensive in the Proterozoic country rocks (fig. 2). These lodes strike dominantly NNW and the recorded dips are mainly subvertical to steep southwesterly. The copper-bearing lodes shown in Figure 2 between Toner River and The Clump are from Ward (1911) who investigated the area when many of the prospects were accessible and the mine at Murrays Reward was operational. He also recorded other similar, but barren, lodes that are not shown in Figure 2. Lodes shown in the Nelson Bay River–Temma district are largely taken from mineral exploration work (e.g. Herrmann and Sumpton, 1982; Perring, 1983; Weber, 1983). These lodes are mostly magnetite-bearing and have been delineated by grid-based ground magnetics and some diamond drilling. The new MRT airborne magnetics and radiometrics show the extent of the individual Temma lodes and their strong discordance relative to the Proterozoic host sequence of quartzite and siltstone.

Together, the Interview Granite and the copper/magnetite lodes characterise the Pieman Heads–Toner River–Nelson Bay River region as a domain of strong NNW structure distinct from regions to the east and north. Granite intrusion and development of the lode structures occurred in similar regimes of extension across the strong NNW trend, and probably in the same general period, although the presence of a copper lode in the contact of a WNW-trending Proterozoic dolerite dyke at Interview River suggests that pre-existing structures were reactivated in places. The lode formations also display shearing subparallel to their strike and dip, with accompanying late alteration (Ward, 1911; Weber, 1983; Turner, 1999).

The southeast margin of the Pieman Heads–Toner River–Nelson Bay River structural domain is marked by the younger, NNE-striking Pieman and Donaldson Faults, with the Donaldson Fault displacing the Pieman Heads Granite and the Pieman Fault appearing to displace the Interview Granite. However where The Clump line of copper lodes is crossed by the NNE-striking Roger River Fault at the northeast margin of the structural domain there does not appear to be displacement of either structure (Everard *et al.*, 2002; Ward, 1911). Southwest of the intersection the Roger River Fault curves to the south and merges with a NNW-trending fault that is parallel to the lode structure (Everard *et al.*, 2003).

Tin/tungsten mineralisation in the Pieman Heads–Toner River–Nelson Bay River region has a more localised distribution than the copper-bearing and magnetite-bearing lodes. Within the Interview Granite there are a series of short, NNE-trending quartz vein lodes that carry wolframite and subordinate cassiterite (Ward, 1911; fig. 2). The lodes lie obliquely along a NNW-trending zone that also contains tourmaline-bearing veins. At Specimen Hill

and Tims Ridge, near Balfour, cassiterite and subordinate wolframite occur in massive, shallowly dipping, quartz veins and in tourmalinised breccia related to a NNW-trending fault, while tin is also present in laminated shale at concentrations of 100–1000 ppm (Patterson, 1996). Gravity interpretation suggests that the mineralisation is located above a relatively near-surface granitoid (Morrison, 1991; Russell and Tear, 1997). Anomalous tungsten is known from surface sampling near Temma (Perring, 1983).

## Mineralisation

### COPPER-BEARING LODES

Metallic minerals in the copper-bearing lodes are mostly pyrite, chalcopyrite, covellite and chalcocite, with rare galena and sphalerite (Ward, 1911). Stibnite occurs in a cross-trending lode near Dohertys Pimple while magnetite and hematite are locally common in lodes near the Poseidon, at Balfour South and Interview River. Gangue minerals are ferroan dolomite, quartz, chlorite and sericite. Wall rocks may display one or more of chloritic, siliceous, sericitic and hematitic alteration. Lead isotope studies of copper mineralisation from Murrays Reward favour a Devonian age for the mineralisation, but with a likely ultimate source for the lead in older, high-grade metamorphic rocks (Dean, 1992).

Most modern mineral exploration has been carried out between Balfour South and The Clump, with the area around Murrays Reward as the principal focus. Drilling between Murrays Reward and Central Mt Balfour returned a number of intersections including 17.3 m at 1.06% Cu (McIntyre, 1971; Russell and Tear, 1997). The mineralisation consists of disseminated, blebby and semi-massive chalcopyrite in a quartz and dolomite gangue. Copper grades at depths greater than 120 m have not been definitively tested.

### MAGNETITE-BEARING LODES

No modern work has been carried out on the magnetite-bearing lodes at Poseidon, Balfour South and Interview River, but there has been considerable work on the magnetite-bearing lodes around Temma and Nelson Bay River (e.g. Herrmann and Sumpton, 1982; Weber, 1983; Newnham, 2000a,b). These lodes consist of magnetite, quartz, ferroan dolomite or siderite, Fe-rich amphibole (grunerite), pyrite and chlorite. The proportions of carbonate, pyrite and amphibole vary considerably within, and between, lodes. Garnetiferous assemblages occur in the lodes and wall rocks, but they commonly display chlorite retrogression associated with shearing. The primary lode assemblage is interpreted as pyrometasomatic (skarn), with late formation of carbonate, sericite and chlorite (Weber, 1983; Dove, 1988), while the rocks replaced by the skarn assemblage were possibly mafic or ultramafic dykes (Newnham, 2000a).

A little copper was mined at Strickland in the early days but metals are generally thinly and erratically

distributed in the magnetite-bearing lodes. They include gold to 2.2 g/t, silver to 22 g/t, copper to 0.4%, lead to 1.84%, arsenic to 1.67% and anomalous zinc. Copper-bearing lodes similar to the lodes between Toner River and The Clump are also present in the Temma district at Couta, Little Eel and Possum. At Little Eel and Possum they occur adjacent to the magnetite-bearing lodes, suggesting that these are structural zones that have experienced repeated mineralising events. The relative age of the copper-bearing and magnetite-bearing lodes has not been established.

Reid (2003) has identified an HEM anomaly in MRT's new airborne EM data that coincides with the southern end of the Strickland East magnetite-bearing lode (fig. 2). This locality also coincides with the edge of an area of Tertiary basalt (Seymour and Reed, 2003), and the anomaly may not be related to the mineralisation.

#### TIN-BEARING LODES

As well as occurring with tungsten in shallowly dipping, massive quartz veins at Specimen Hill (fig. 2) and at nearby Tims Ridge, and in tourmalinised breccia at Specimen Hill, tin occurs at high grades in sulphide-bearing veins to the east and south of Specimen Hill. Particularly high-grade material containing 8.6% Sn, 8.2% W, 4.31% As and 0.25% Cu occurs at Robbies workings, while material containing 0.91% Sn, 0.1% W, 3.31% As, 1.62% Cu, 0.15% Pb, 9.94% Zn and 135 g/t Ag occurs at Tatlows workings (Turner, 1994).

Lead isotope studies of pyritic Sn-W-Pb mineralisation from the Tatlows/Robbies workings favoured a Devonian age for the deposits, but with an ultimate source of the lead in older, high-grade metamorphic rocks (Dean, 1992). Although the lead isotope studies favour a Devonian age for both the tin-bearing lodes and the copper-bearing lodes, it is likely that they represent different episodes of mineralisation within that period. The copper-bearing lodes are regionally extensive, have relatively simple mineralogy (although they contain low order anomalous tin in places) and are probably of lower temperature. In comparison, the tin-bearing lodes are restricted in occurrence, probably of higher temperature, are strongly polymetallic and show evidence of zonation. The two types of mineralisation are closely juxtaposed at Murrays Reward where drilling encountered cassiterite stringers up-hole from the copper mineralisation (Russell and Tear, 1997).

Robbies and Tatlows appear to be small occurrences of tin mineralisation, but they add to the potential of the area in a bulk sense. Reid (2003) has identified an HEM anomaly associated with Robbies workings in MRT's new airborne EM data. HEM anomalies are also associated with Sn-Pb-Cu and Cu lodes 1.5 km SSW of Specimen Hill. As pointed out by Patterson (1996), exploration of the Specimen Hill prospect is a sampling problem. He regarded the previous attempts to establish grade/tonnage figures for the veins and breccia on Specimen Hill by costeaning, bulk

chip-sampling and by NQ diamond drilling as unreliable and proposed systematic RC drilling as a better method. As well as Specimen Hill itself, there are several square kilometres around Specimen Hill that offer potential for significant tin mineralisation, both in vein developments and in the interesting laminated shales with their elevated levels of tin.

#### OTHER MINERALISATION

Other distinctive mineralisation to the south of Specimen Hill includes a polymetallic lode in the old Mineral Section 4262 (fig. 2; Ward, 1911) that contains copper, lead, zinc, silver and trace gold. West of Specimen Hill there are a number of long ( $\geq 1$  km), linear, north-trending, Pb/Zn 'wacker' soil anomalies that are yet to be tested by drilling (Tear and Russell, 1997). At the Interview River there is a northwest-trending lode containing argentiferous galena with trace chalcopyrite in a gangue of quartz and chlorite (fig. 2; Ward, 1911). Similar mineralisation in the same locality has been investigated in more recent years by Abignano Limited.

#### Conclusions

The Pieman Heads-Toner River-Nelson Bay River region of northwest Tasmania is a structural domain in which outcropping Devonian granitoid (Interview Granite) and narrow, copper-bearing and magnetite-bearing lodes are controlled by steeply dipping fractures of predominantly NNW trend. At least one of the copper-bearing lodes occupies a reactivated older structure, namely the contact of a Proterozoic dolerite dyke.

The copper-bearing lodes are regionally extensive and have a simple mineralogy of essentially chalcopyrite, covellite, chalcocite and pyrite in a gangue of quartz, ferroan dolomite and chlorite. Near Balfour the copper-bearing lodes are in juxtaposition with a regionally restricted system of cassiterite-wolframite-sulphide veins and mineralised breccia. Lead isotope studies favour a Devonian age for both the copper and tin mineralisation, but they probably represent different mineralising episodes within that period. The regionally restricted polymetallic tin mineralisation is thought to be related to a granitoid cupola that underlies the Balfour district at relatively shallow depth. The much more simple copper lodes show a uniformity of regional structural control that suggests they were formed at a different, possibly earlier time.

Considerable opportunities exist for further mineral exploration in the Balfour district. The grade of the copper-bearing lodes near Balfour has not been definitively tested below about 120 metres. Other opportunities for drill-testing of the copper-bearing lodes may exist at Balfour South and Dohertys Pimple. Previous attempts to determine grade/tonnage figures for the tin mineralisation at Specimen Hill have not been satisfactory and systematic RC drilling is recommended. Further tin potential exists in an area of several square kilometres around Specimen Hill. In

particular, three HEM anomalies over known tin and copper mineralisation have been identified within this area by MRT's airborne EM survey. To the west of Specimen Hill there are lead-zinc anomalies of  $\geq 1$  km length that have not been tested by drilling.

The NNW-trending lodes near Temma and Nelson Bay River are mostly magnetite skarn, possibly replacing Proterozoic dolerite dykes. They contain erratic copper, lead, silver, arsenic and gold. Whether these metals are associated with the primary skarn assemblage or with later, sheared, carbonate-chlorite alteration is unknown. The magnetite-bearing lodes show the same uniform regional structural control that is exhibited by the copper-bearing lodes, which are also present in the Temma district, and it is likely that the lodes are of similar age. The relatively high temperature, pyrometamorphic character of the magnetite-bearing lodes suggests that their igneous source is present at shallow depth beneath the district. Alternatively, structure was particularly effective in aiding the circulation of the hot mineralising fluids.

An attractive exploration opportunity for gold exists along the NNE-trending regional fault complex that extends through Corinna and Specimen Reef (fig. 1, 2). Gold-bearing alteration systems are associated with the segments of the fault complex at Brookside and Specimen Reef, and potentially reactive Neoproterozoic carbonate formations are cut by the complex in the intervening belt of country. A similar exploration opportunity exists along the NNE-trending Roger River Fault where the geological setting is similar to Brookside. There is extensive silicification of Neoproterozoic carbonate rocks with associated metal anomalism that includes mercury and barite. Aspects of the Brookside system are consistent with the Carlin style of mineralisation.

The presence of an altered, gold-bearing, granitic intrusion breccia at Lucy Spur and the nearby presence of a dated Devonian granitic porphyry at Timbs Creek indicate that Devonian magmatism and mineralising fluids were capable of reaching locations that are relatively remote from the major granitoid bodies, as they are currently modelled. This has important implications in terms of raising the prospectivity of the rocks in northwest Tasmania for granite-related mineralisation. In particular, the potentially reactive Neoproterozoic carbonate rocks (fig. 1), especially in locations close to regional faults that may have acted as conduits for mineralising fluids.

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## References

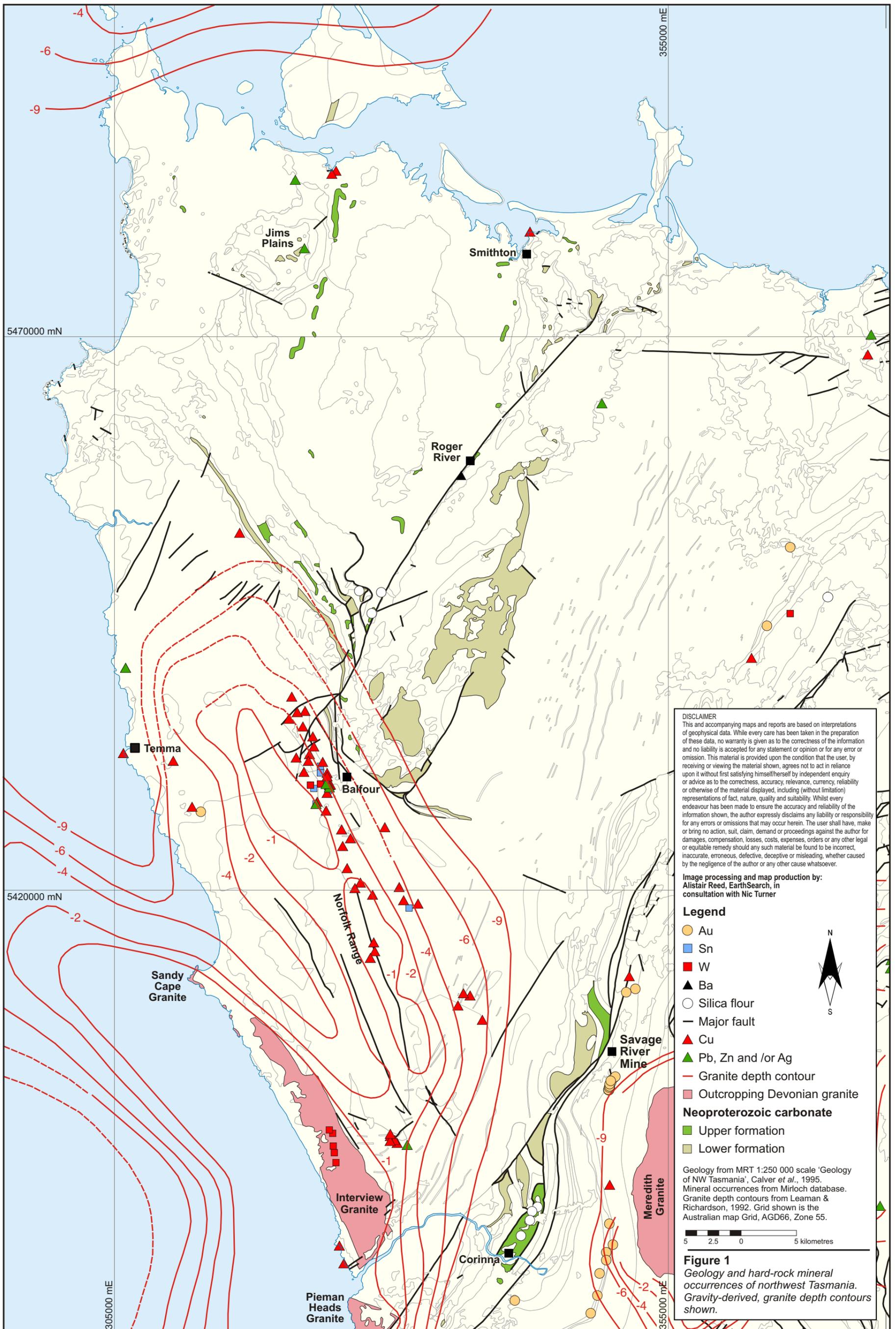
- ANDERSON, J. A. 1986. The geology of the Zeehan cassiterite-sulphide deposits, Tasmania, in: Genesis of tin-tungsten deposits and their associated granitoids. Proceedings of joint meeting of working groups 2 and 4. IGCP project 220. 1-2. *Record Bureau of Mineral Resources Australia* 1986/10
- BLAKE, F. 1939. Report on Corinna alluvial goldfield. *Unpublished Report Department of Mines Tasmania* 1939:26-46.
- BOTTRILL, R. S.; HUSTON, D. L.; TAHERI, J.; KHIN ZAW. 1992. Gold in Tasmania. *Bulletin Geological Survey Tasmania* 70:24-26.
- COLLINS, P. L. F.; BROWN, S. G.; DRONSEIKA, E. V.; MORLAND, R. 1989. Mid-palaeozoic ore deposits, in: BURRETT, C. F.; MARTIN, E. L. (ed.). Geology and mineral resources of Tasmania. *Special Publication Geological Society of Australia* 15:270-292.
- DEAN, J. A. 1992. The Pb isotopic composition of mineralisation from the Balfour prospect, western Tasmania. *Sirotope report CSIRO Division of Exploration Geosciences* SR 237.
- DOVE, A. 1988. EL7/87. *Annual report on exploration completed in the Nelson River area of western Tasmania to 26/6/87*. Bach Holdings Pty Ltd [TCR 88-2823].
- EVERARD, J. L.; REED, A. R.; SEYMOUR, D. B.; CALVER, C. R. 2002. *Geological Atlas 1:25 000 Digital Map Series. Sheet 3243. Dempster*. Mineral Resources Tasmania.
- EVERARD, J. L.; REED, A. R.; SEYMOUR, D. B. 2002. *Geological Atlas 1:25 000 Digital Map Series. Sheet 3242. Balfour*. Mineral Resources Tasmania.
- GEE, R. D.; GULLINE, A. B.; BRAVO, A. P.; LEGGE, P. J.; GROVES, D. I. 1969. *Geological Atlas 1 mile Series. Sheet 42 (7814N). Pieman Heads*. Department of Mines, Tasmania.
- GREEN, G. R.; BOTTRILL, R. S.; BACON, C. A.; TURNER, N. J. 1988. *Mineral deposits and metallogenic map of Tasmania*. Department of Mines, Tasmania.
- HENHAM, R. J. 1990. *Mining leases 98-102M/84 Brookside, western Tasmania. Report on exploration to 24 January 1990*. Aberfoyle Exploration [TCR 90-3106].
- HERRMANN, W. 1991a. *Annual report to 26 May, 1991. EL14/89 - Corinna, Tasmania*. Outokumpu Exploration Australia Pty Ltd [TCR 91-3256].
- HERRMANN, W. 1991b. *Annual report to 6 April, 1991. EL56/89 - Corinna South, Tasmania*. Outokumpu Exploration Australia Pty Ltd [TCR 91-3269].
- HERRMANN, W.; SUMPTON, J. 1982. *Progress report EL1/77 Temma area 1981*. Geopeko [TCR 82-1721].
- JENNINGS, I. B. 1965. Middlesex mineral district. *Proceedings Eighth Commonwealth Mining and Metallurgy Congress* 1:512-514.
- JULEN, H. 1981. *A history of gold mining on the Tasmanian west coast*. Regal Press : Launceston.
- KHIN ZAW; TURNER, N. J.; LARGE, R. R.; NOLAN, H.; MERNAGH, T. 1992. Geology and genesis of silica flour and gold in the Corinna district, western Tasmania. *Bulletin Geological Survey Tasmania* 70:96.

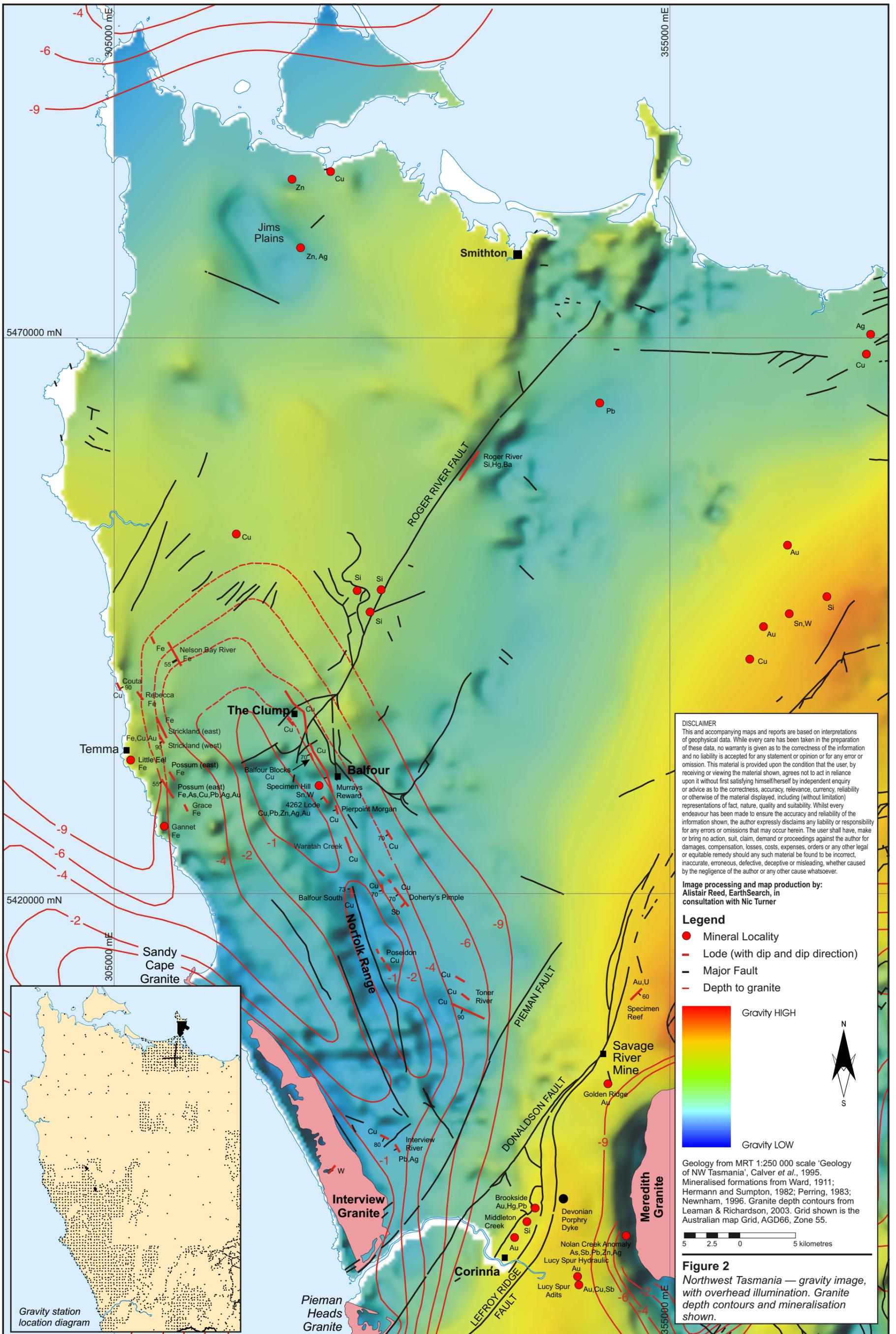
- KITTO, P. A. 1996. *A petrographic and geochemical investigation of gold: Arthur Mobile Belt, western Tasmania*. Consultants Report, Centre for Ore Deposit and Exploration Studies University of Tasmania, for Goldstream Mining NL [TCR 97-4074].
- KITTO, P. A. 1997. *Petrographic descriptions of alteration assemblages and consequences for ore genesis at the Brookside prospect: Arthur Mobile Belt, western Tasmania. Report for Goldstream Mining NL and Titan Resources NL*. Centre for Ore Deposit and Exploration Studies, University of Tasmania [TCR 97-4101A].
- LARGE, R. R. 1987. *An assessment of the data on the Brookside gold prospect, Corinna district*. Unpublished Report for Cominex Pty Ltd.
- LEACH, T.; CORLETT, G. 1998. Petrographic analysis of four adit samples from the Lucy Spur project, Tasmania. Appendix 12 in: TURNER, N. J. 1998. *EL43/94 Corinna Western Tasmania. Annual Report to 4/1/99*. Goldstream Mining NL, Titan Resources NL [TCR 99-4261].
- LEAMAN, D. E. 1998. *Comments on airborne geophysical data, EL26/95 Specimen Creek, W Tasmania*. Goldstream Mining NL, Titan Resources NL [TCR 98-4288A].
- LEAMAN, D. E.; RICHARDSON, R. G. 1992. A geophysical model of the major Tasmanian granitoids. *Report Department of Mines Tasmania 1992/11*.
- LEAMAN, D. E.; RICHARDSON, R. G. 2003. A geophysical model of the major Tasmanian granitoids. *Record Tasmanian Geological Survey 2003/11*.
- LENNOX, P. G.; CORBETT, K. D.; BAILLIE, P. W.; CORBETT, E. B.; BROWN, A. V. 1982. *Geological Atlas 1:50 000 Series. Sheet 21 (7916S)*. Smithton. Department of Mines Tasmania.
- MCINTYRE, M. H. 1971. *Mineral exploration in EL16/68 Balfour, north-west Tasmania, 1970-1971*. Australian Consolidated Industries Ltd [TCR 73-0947].
- MORLAND, R. 1989. Renison Bell tin mine, in: BURRETT, C. F.; MARTIN, E. L. (ed.). *Geology and mineral resources of Tasmania. Special Publication Geological Society of Australia 15:276-278*.
- MORRISON, K. 1991. *Exploration Licence 53/88, Mount Frankland. Annual report : Year 3 (6 January 1991-5 January 1992)*. Soloriens Mining Pty Ltd [TCR 91-3315].
- MORRISON, K. 2002. Greenstone Resources NL Roger River Project. Smokers Bank-Copper Creek area. Exploration mapping and sampling report. Greenstone Resources NL [TCR 02-4646B].
- MORRISON, K. C.; REED, A. R.; TURNER, N. J. 2003a. Western Tasmanian Regional Minerals Program Devonian Granite Aureoles Project. Regional map set and geophysical signatures. *Record Geological Survey Tasmania 2003/13*.
- MORRISON, K. C.; REED, A. R.; TURNER, N. J. 2003b. Western Tasmanian Regional Minerals Program Devonian Granite Aureoles Project. The Dolcoath Granite: A gold exploration target. *Record Geological Survey Tasmania 2003/16*.
- MORRITT, R. F. C. 1997. *North-west Tasmania – Australia. An exploration opportunity for gold, copper and diamonds*. Pacific-Nevada Mining Pty Ltd [TCR 01-4563].
- NEWNHAM, L. A. 1996. *EL26/95 Specimen Reef area, western Tasmania. Review of previous data*. Goldstream Mining NL, Titan Resources NL [TCR 97-4075A].
- NEWNHAM, L. A. 2000a. *EL15/1997 Arthur River. Report on Nelson Bay drilling program, June-July 2000*. Pacific-Nevada Mining Pty Ltd [TCR 00-4494].
- NEWNHAM, L. A. 2000b. *EL27/97 – Temma. Strickland drilling program, July 2000*. Pacific-Nevada Mining Pty Ltd [TCR 00-4500].
- NOLAN, H. D. 1996. *Microscopic examination of gold particles in panned concentrate samples*. Goldstream Mining NL, Titan Resources NL [TCR 97-4074A].
- PATTERSON, G. W. 1996. *A review of exploration at Specimen Hill, Balfour, Tasmania*. CRA Exploration Pty Ltd [TCR 96-3912A].
- PENNY, B. G.; SHANNON, C. H. C.; VANZINO, L. 1984. *Report on field investigations within Exploration Licence 4/61, west coast, Tasmania. Summer field season 1983-1984*. Industrial and Mining Investigations Pty Ltd [TCR 84-2262].
- PERRING, R. J. 1983. *EL1/77 Rocky Cape. Temma area progress report 1 August 1982 to 31 July 1983*. Geopeko [TCR 84-2151].
- REID, J. 2003. Western Tasmanian Regional Minerals Program. Helicopter electromagnetic data (HEM) – processing, quality control and interpretation. *Record Tasmanian Geological Survey 2003/09*.
- RUSSELL, S. A. J.; TEAR, S. J. 1997. *EL4/94 Balfour. Third and final report for the period 3 May 1996 to 11 November 1997, Tasmania, Australia*. Rio Tinto Exploration Pty Ltd [TCR 98-4115].
- SEYMOUR, D. B.; BAILLIE, P. W. 1992. *Geological Atlas 1:50 000 Series. Sheet 20 [7816S]*. Woolnorth. Department of Mines, Tasmania.
- SEYMOUR, D. B.; CALVER, C. R. 1995. Explanatory notes for the Time-Space Diagram and Stratotectonic Elements Map of Tasmania. *Record Tasmanian Geological Survey 1995/01*.
- SEYMOUR, D. B.; REED, A. R. 2003. *Geological Atlas 1:25 000 Scale Digital Series. Sheet 3043. Temma*. Mineral Resources Tasmania.
- SHARPE, R. 1998. *Petrographic investigation of the alteration and vein assemblages at the Specimen Creek prospect, Arthur Mobile Belt, western Tasmania. Report to Goldstream Mining NL and Titan Resources*. CODES SRC, University of Tasmania [TCR 99-4288B].
- TEAR, S. J.; RUSSELL, S. A. J. 1997. *EL18/92 Mt Frankland. Fifth and final annual report for the period from 6 October 1996 to 11 November 1997, Burnie SK 55-03, Tasmania, Australia*. Rio Tinto Exploration Pty Ltd [TCR 98-4121].
- TERRY, B. 1998. Lucy Spur and Rocky River prospects: Notes on geology, old workings, soil and rock samples. Appendix 1 in: TURNER, N. J. 1998. *EL43/94 Corinna Western Tasmania. Annual Report to 4/1/99*. Goldstream Mining NL, Titan Resources NL [TCR 99-4261].
- TURNER, N. J. 1994. *Report on geological mapping and rock chip sampling around The Clump, Murrays Reward and other localities in EL18/92, Balfour district, north western Tasmania*. N J Turner Geological Services for CRA Exploration Pty Ltd [TCR 95-3734A].
- TURNER, N. J. 1997a. *Brookside Prospect comprising CML7M97 and EL43/96 Pieman River. Annual report to 29.10.97*. N J Turner Geological Services for Goldstream Mining NL and Titan Resources NL [TCR 97-4101].
- TURNER, N. J. 1997b. *Exploration Licence 43/94 Corinna, western Tasmania. Annual report to 4.1.98*. Goldstream Mining NL, Titan Resources NL [TCR 97-4108].
- TURNER, N. J. 1997c. *Exploration Licence 26/95 Specimen Creek, western Tasmania. Annual report to 6/3/98*. Goldstream Mining NL, Titan Resources NL [TCR 97-4107].

- TURNER, N. J. 1998. *EL42/96 Rocky River, western Tasmania. Annual report to 29.10.98*. Goldstream Mining NL, Titan Resources NL [TCR 98-4219].
- TURNER, N. J. 1999. *EL27/97 Temma. Annual report to 12.11.99*. Pacific-Nevada Mining Pty Ltd [TCR 99-4387].
- TURNER, N. J. 2003. *Morrith Holdings Pty Ltd Roger River Project. ELs11/97, 12/97, 13/97, 14/97, 61/94 and 17/01. Combined annual report to 18 December 2002*. N J Turner Geological Services Pty Ltd [TCR 03-4841].
- TURNER, N. J.; BLACK, L. P.; KAMPERMAN, M. 1998. Dating of Neoproterozoic and Cambrian orogenies in Tasmania. *Australian Journal of Earth Sciences* 45:789-806.
- TWELVETREES, W. H. 1903. Report on mineral fields between Waratah and Long Plains. *Old Series Report Department of Mines Tasmania* 207.
- WARD, L. K. 1911. The Mt Balfour mining field. *Bulletin Geological Survey Tasmania* 10.
- WEBER, G. B. 1983. *Rocky Cape EL1/77. Progress report on the Temma area. January 1983*. CRA Exploration Pty Ltd [TCR 83-1958].
- WEBSTER, S. 2002. Quantitative interpretation of magnetic and gravity data for the Western Tasmanian Regional Minerals Program, Part 2. *Record Tasmanian Geological Survey* 2002/15.

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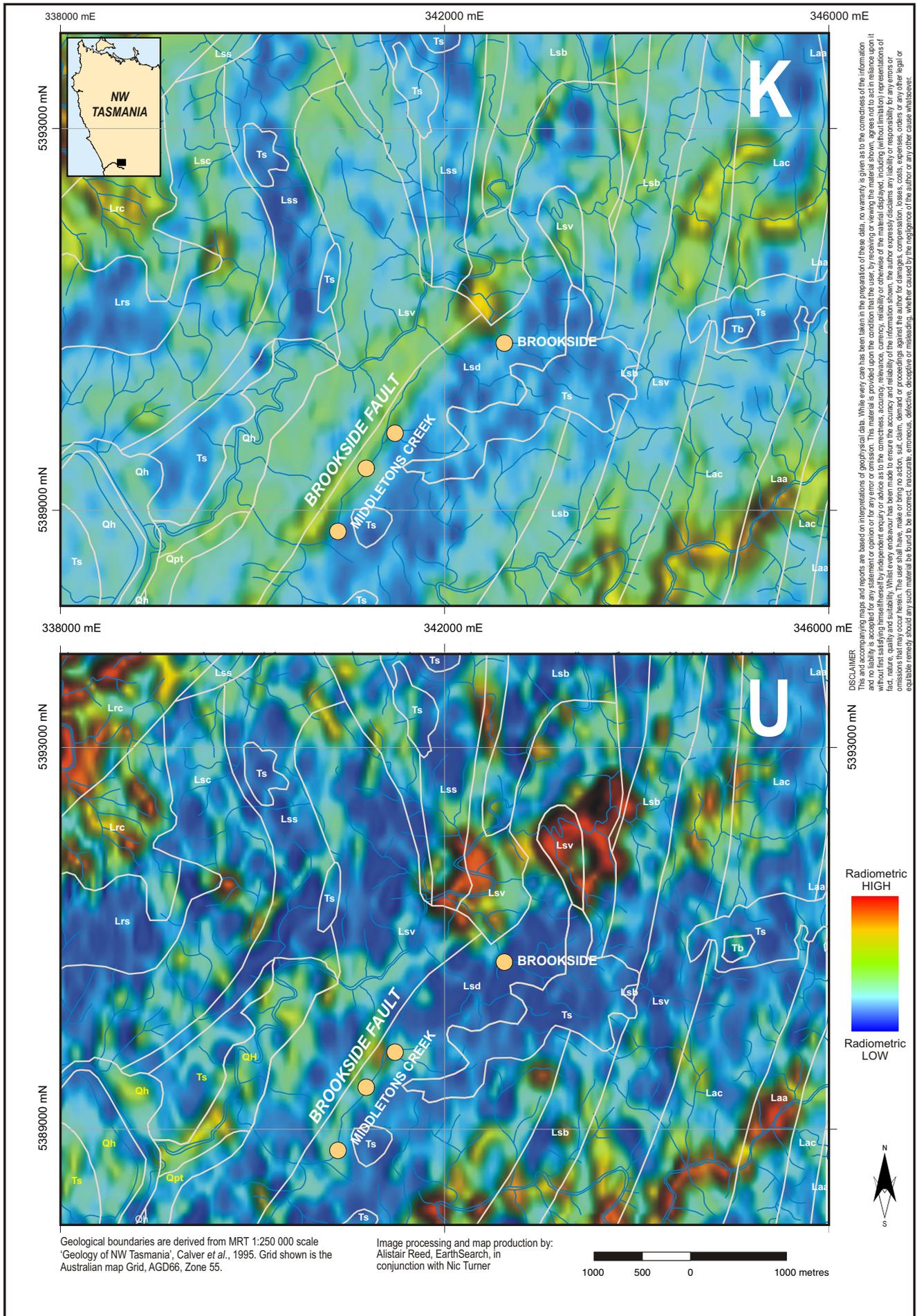


Figure 3. Brookside region, NW Tasmania: K and U radiometric images, with overhead illumination